

What is claimed is:

- SH
AI
1. An audio signal processing system for enhancing speech signal intelligibility for the hearing impaired in the presence of system noise, ambient noise, program background noise, and particular hearing impairments, the system comprising:
 - a. a source of audio signals,
 - b. a speech enhancement system comprising a speech processing unit and a speech signal bypass circuit,
 - c. an output signal amplifier,
 - d. and at least one output speaker,
 - e. wherein the source of audio signals is connected to the speech enhancement system which either processes the speech signal in the speech processing unit to enhance the intelligibility of the speech signals for the hearing impaired before connection to the output signal amplifier and one or more output speakers, or bypasses the audio signals directly to the output signal amplifier and one or more speakers, the bypass option and speech enhancement processing operations being under user control.
 2. The audio signal processing system of Claim 1 wherein the speech enhancement system comprises:
 - a. remote control and audio/video input signals connected to an input circuit,
 - b. a central processing unit,

- c. an output audio circuit for connection to external amplifiers,
- d. an adaptive filter for suppression of system, ambient, and/or interfering background noise present in the input audio signal, and/or for compensating for specific hearing loss parameters for selected hearing impaired listeners,
- e. a hearing test system,
- f. an equalization/compensation system to optimize the audio signal for selected room acoustics and hearing impairment profiles of particular users,
- g. a speech recognition system to recognize spoken words,
- h. a lip reading computer vision system,
- i. an expert system to assist in the recognition of spoken words based on context,
- j. a speech synthesis system,
- k. wherein the central processing unit includes switching and control circuits for interconnecting the input circuit audio/visual input signals to the adaptive filter, the equalization/compensation circuit, the hearing test system, the speech recognition system, the lip reading expert system and the output circuits to provide user selected signal enhancement to improve the intelligibility of the audio signal for selected hearing impaired users.

3. The audio signal processing system of Claim 2 wherein the adaptive filtering system includes a noise estimator that provides noise estimates to an adaptive filter circuit to provide optimum noise suppression in the output audio signal.
4. The audio signal processing system of Claim 2 wherein the hearing test system provides control signals to the speech enhancement system to optimize audio signal filter parameters for specific individual hearing impairments.
5. The audio signal processing system of Claim 4 wherein the control signals are input from a remote source.
6. The audio signal processing system of Claim 4 wherein at least some of the control signals are derived based on a locally administered hearing tests.
7. The audio signal processing system of Claim 2 wherein at least some of the system control signals are input via a user remote control unit.
8. The audio signal processing system of Claim 7 wherein the remote control unit includes a screen to display spoken words in textual format.
9. The audio signal processing system of Claim 2 wherein the output of the speech recognition system is input to the speech synthesis system to generate audible spoken words for the hearing impaired.
10. The audio signal processing system of Claim 2 wherein the expert system is programmed to enhance speech recognition operations based on the context of the spoken words.

11. A method of audio signal processing for enhancing speech signal intelligibility in the presence of system noise, ambient noise, program background noise, and particular hearing impairments for the hearing impaired comprising the acts of:

- a. providing a source of audio signals,
- b. enhancing the intelligibility of speech signals in the audio signals using a speech enhancement system comprising a speech processing unit and a speech signal bypass circuit,
- c. amplifying processed speech signals or bypassed speech signals with an output signal amplifier,
- d. providing at least one output speaker,
- e. and connecting the source of audio signals to the speech enhancement system which either processes the speech signal in the speech processing unit to enhance the intelligibility of the speech signals for the hearing impaired before connection to the output signal amplifier and one or more output speakers, or bypasses the audio signals directly to the output signal amplifier and one or more speakers, the bypass option and speech enhancement operations being under user control.

12. The method of audio signal processing for enhancing speech signal intelligibility for the hearing impaired of Claim 11 further comprising the acts of:

- a. connecting remote control and audio/video input signals to an input circuit,
- b. providing a central processing unit,
- c. providing an output audio circuit for connection to external amplifiers,
- d. suppressing system ambient, and/or interfering background noise present in the input audio signal, and/or compensating for specific hearing loss parameters for selected hearing impaired listeners using adaptive filtering,
- e. providing an integrated hearing test system for testing the hearing of users,
- f. providing an equalization/compensation system to optimize the audio signal for selected room acoustics and hearing impairment profiles of particular users,
- g. providing a speech recognition system to recognize spoken words,
- h. providing a lip reading computer vision system,
- i. providing an expert system to assist in the recognition of spoken words based on context,
- j. producing audible speech using speech synthesis,
- k. using the central processing unit switching and control circuits for interconnecting the input circuit audio/visual input signals to the adaptive filter, the equalization/compensation circuit, the hearing test system, the speech recognition system, the lip reading expert system and

the output circuits to provide user selected signal enhancement to improve the intelligibility of the audio signal for selected hearing impaired users.

13. The method of audio signal processing for enhancing speech signal intelligibility for the hearing impaired of Claim 12 further comprising the act of using adaptive filtering including a noise estimator that provides noise estimates to an adaptive filter circuit for optimum noise suppression in the output audio signal.
14. The method of audio signal processing for enhancing speech signal intelligibility for the hearing impaired of Claim 12 further comprising the act of using hearing tests of users to provide control signals to the speech enhancement system to optimize audio signal filter parameters for specific individual hearing impairments.
15. The method of audio signal processing for enhancing speech signal intelligibility for the hearing impaired of Claim 14 wherein the control signals are input from a remote source.
16. The method of audio signal processing for enhancing speech signal intelligibility for the hearing impaired of Claim 14 wherein at least some of the control signals are derived based on a locally administered hearing tests.
17. The method of audio signal processing for enhancing speech signal intelligibility for the hearing impaired of Claim 12 wherein at least some of the system control signals are input via a user remote control unit.

18. The method of audio signal processing for enhancing speech signal intelligibility for the hearing impaired of Claim 17 wherein the act of using a remote control unit includes the use of a screen to display spoken words in textual format.
19. The method of audio signal processing for enhancing speech signal intelligibility for the hearing impaired of Claim 12 wherein the act of using the output of the speech recognition system includes the further act of generating input to the speech synthesis system to create audible spoken words for the hearing impaired.
20. The method of audio signal processing for enhancing speech signal intelligibility for the hearing impaired of Claim 12 wherein the act of using the expert system includes programming the system to enhance speech recognition operations based on the context of the spoken words.
21. A speech enhancement system for enhancing a speech component of an audio presentation for a hearing impaired listener, the system comprising:
- a. source of audio presentation containing an audio signal comprising a speech component and a noise component;
 - b. central processor including a data storage module, an input section receiving the audio signal and an output section;
 - c. an adaptive filter circuit connected to central processor, the adaptive filter circuit including a noise cancellation circuit for canceling or minimizing the noise component of the audio signal;

- d. an amplifier system connected to the output section of the central processor;
 - e. a menu driven remote control unit for selective control of the speech enhancement system for enhancing the speech component of the audio signal to improve intelligibility for a hearing impaired user.
22. The system set forth in Claim 21 further comprising an equalization circuit connected to the central processor and to the data storage module of the central processor for equalizing room or listening area acoustics to further improve speech intelligibility for the hearing impaired user.
23. The system set forth in Claim 22 further comprising a hearing test module in communication with the central processor and the data storage module of the central processor for testing the hearing of a hearing impaired user and using the results of such test to further process the audio signal to improve the speech intelligibility for the hearing impaired user.
24. A speech enhancement system for enhancing a speech component of an audio presentation for a hearing impaired listener, the system comprising:
- a. a central processor including a data storage module, an input section receiving the audio presentation and an output section;
 - b. a signal processing system including an adaptive filter used to reduce system noise and background noise components from the audio signal to enhance speech recognition,

c. speech recognition module in communication with the central processor;

d. user controlled visual display device, the output device of the central processor connected to the visual display device for selective display of text output of the signal processing system and speech recognition module under user control.

25. The system as set forth in Claim 24 further comprising an expert system module in communication with the central processor, the expert system module further communicating with the speech recognition module to assist in speech recognition based on spoken word contextual usage and learned speaking patterns.

26. A speech enhancement system for enhancing a speech component of an audio and visual presentation for a listener, the system comprising:

a. a source of audio visual presentation containing a video component comprising a speaker;

b. a central processor comprising an input section receiving the video presentation and an output section;

c. a visual display device connected to the output section of the central processor;

d. a lip reading module in communication with the central processor for selective interpretation of spoken words.

27. The system as set forth in Claim 26 further comprising an expert system module in communication with the central processor, the expert system module further communicating with the lip reading module to assist in speech recognition based on spoken word contextual usage and learned speaking patterns.

28. A method of processor based speech enhancement for enhancing speech of an audio presentation for the benefit of a listener, the audio presentation including a speech component and a noise component, comprising the acts of:

- a. providing a central processor including an input section for receiving the audio presentation and an output section for delivering a signal;
- b. providing an adaptive filter module for filtering the audio presentation, the adaptive filter module connected to the central processor;
- c. filtering the audio presentation to separate the speech from the noise;
- d. delivering the speech component to the central processor;
- e. providing an equalization circuit for equalizing the speech component of the audio presentation;
- f. providing a target equalization level preferred by the listener;
- g. equalizing the speech component to the target equalization level of the listener;
- h. delivering the equalized speech component to the central processor;

- i. outputting the speech component from the central processor to the output section thereof for the delivery of the speech for the benefit of the listener.
29. The method set forth in Claim 28 wherein the adaptive filter module act comprises using a noise estimator, an adaptive filter circuit and a summing circuit.
30. The method set forth in Claim 29 wherein the adaptive filter module act of filtering the audio presentation comprises the acts of:
- a. directing the audio input, comprised of speech and noise, to the noise estimator;
 - b. directing the audio input to the adaptive filter;
 - c. directing the audio input to the summing circuit;
 - d. identifying the noise component in the noise estimator;
 - e. sending the identified noise component to the adaptive filter;
 - f. separating the noise component from the audio input and retaining the noise component;
 - g. sending the noise component to the summing circuit;
 - h. summing the noise component from the audio signal fed to the summing circuit.
31. The method set forth in Claim 30 wherein the act of identifying the noise component comprises the acts of:

- a. identifying a pattern of speech including speech and speech-free gaps where no speech exists;
 - b. identifying the pattern of sound in the speech-free gaps;
 - c. classifying the pattern of sound in the speech-free gaps as noise.
32. The method set forth in Claim 31 further comprising the act of determining the frequency response capability of a listener.
33. The method set forth in Claim 32 wherein the act of determining the frequency response capability of a listener further comprises the acts of:
- a. screening the listener to determine the hearing capability as measured in dBs of the listener at various frequencies;
 - b. storing the data obtained from screening the listener.
34. The method set forth in Claim 33 further comprising the act of compensation for hearing loss suffered by a user.
35. The method set forth in Claim 34 wherein the act of compensation comprises the acts of:
- a. processing the speech component resulting from the act of summing the noise component from the audio signal fed to the summing circuit to establish a base line zero dB reference point representing the speech component;
 - b. accessing the stored data of the listener;

- c. comparing the base line zero dB reference point of the speech component to the data corresponding to the listener's hearing capability;
 - d. determining the frequencies where the listener's capability is below the base line zero dB reference point of the speech component;
 - e. increasing the dB level of the speech component by the difference between the listener's data and the base line zero dB reference point.
36. The method of Claim 35 further comprising the act of performing a screening of the listener to determine the capacity of the listener to hear the compensated speech.
37. The method of Claim 36 further comprising the act of storing the compensation values necessary to adjust the base line zero dB level to the level required by the listener to sense speech at a level corresponding to the base line zero Db level.
38. The method of Claim 35 wherein the act of screening the listener to determine the hearing capability as measured in dBs of the listener at various frequencies comprises the act of screening the listener and storing the data obtained from screening the listener on transportable media.
39. The method of Claim 38 where the act of accessing the stored data of the listener is performed by accessing the listener data stored on the transportable media through an input port connected to the processor.

40. The method of Claim 35 wherein the act of screening the listener to determine the hearing capability as measured in dBs of the listener at various frequencies comprises the act of screening the listener and storing the data obtained from screening the listener on a data base remote from the processor.
41. The method of Claim 40 where the act of accessing the stored data of the listener is performed by accessing the listener data stored on the database remote from the processor through an input port connected to the processor.
- ~~42.~~ A method of processor based speech enhancement for enhancing speech of an audio presentation for the benefit of a listener, the audio presentation including a speech component and a noise component, comprising the acts of:
- a. providing a central processor including an input section for receiving the audio presentation and an output section for delivering a signal;
 - b. providing adaptive filtering speech processing capability to filter unwanted system and background noise,
 - c. providing speech recognition module for translation of the audio presentation, the speech recognition module connected to the central processor;
 - d. translating the audio presentation in the speech recognition module into a format capable of being displayed in a visually perceptible format;

e. delivering the translation of the audio presentation to an apparatus capable of presenting a user controlled, visually perceptible format of the translated speech.

43. The method set forth in Claim 42 wherein the apparatus capable of presenting the visually perceptible is a television.

44. The method set forth in Claim 42 wherein the apparatus capable of presenting the visually perceptible is a dedicated display in communication with the central processor.

45. A method of processor based speech enhancement for enhancing speech of a video presentation for the benefit of an observer, the video presentation including sound generating characters comprising the acts of:

a. providing a central processor including an input section for receiving the video presentation and an output section for delivering a signal;

b. providing lip reading module for translation of the sounds generated by the sound generation characters in the video presentation, the lip reading module connected to the central processor;

c. interpreting the video presentation using the lip reading module into a format capable of being displayed in a visually perceptible format;

d. delivering the translation of the video presentation to an apparatus capable of presenting the visually perceptible format of the translated speech.

46. The method set forth in Claim 45 further comprising the act of providing an expert system module in communication with the central processor.
47. The method set forth in Claim 46 wherein the expert system module performs the act of augmenting the capability of the lip reading module by performing the act of providing expert system analysis to the output of the lip reading module to increase the accuracy of the lip reading module output.
48. A method of improving the quality of life of a hearing impaired person and others in the immediate vicinity of the hearing impaired person by performing the act of enhancing the speech component of an audio presentation for the benefit of a hearing impaired person by compensation of the speech component of the audio presentation to yield a compensated audio presentation that does not require a significant increase in the dB level of the audio presentation to allow the hearing impaired person to perceive virtually all of the audible frequencies in the audio presentation at a dB level tolerable by the others in the immediate vicinity of the hearing impaired person.